FY 2009 Annual Report
National Program 211 - Water Availability and Watershed Management

Introduction

Water is fundamental to life and a basic requirement for virtually all of our agricultural, industrial, urban, and recreational activities, as well as for the sustained health of our natural ecosystems.

Global Climate, Biofuels and Food Security - During 2009, global concerns about climate changes have come to the forefront and National priorities have increased to meet the growing demand for renewable biofuel feed stocks. Both issues have significant consequences for water availability and quality. The earth's human population tripled during the last century and global demand for its finite supply of available fresh water increased six-fold. Global food security is intimately tied to the availability of water. The United Nations estimates that more than a billion people live without access to clean water, and more than 2.4 billion people lack the basic sanitation needed for human health. In advanced economies, clean water availability has become increasingly threatened due to contamination from agriculture (crop fertilization and animal manure), urban sources (storm runoff, pharmaceutics, disinfection byproducts) and industry. Against these serious and growing problems, the importance of conserving water resources has never been greater.

The goal of the USDA/ARS Water Availability and Watershed Management National Program is to manage water resources effectively and safely, while protecting the environment and human and animal health. This goal will be achieved by characterizing potential hazards, developing management practices, strategies and systems to alleviate problems, and providing practices, technologies and decision support tools for the benefit of customers, stakeholders, partners, and product users. Research in this National Program addresses six component problem areas: (1) the effectiveness of conservation practices; (2) irrigation water management; (3) drainage water management systems; (4) integrated soil erosion and sedimentation technologies; (5) watershed management, water availability, and ecosystem restoration; and (6) water quality protection systems.

The mission of this National Program is twofold: (1) to conduct research on the processes that control water availability and quantity for the health and economic growth of U.S. citizens; and apply the new knowledge (2) to develop new and improved technologies for managing the Nation's agricultural and water resources. Advances in knowledge and technologies provide producers, action agencies, local communities, and resource advisors with the practices, tools, models, and decision support systems they need to improve water conservation and water use efficiency in agriculture, enhance water quality, protect rural and urban communities from the ravages of drought and floods, improve agricultural and urban watersheds, and prevent the degradation of riparian areas, wetlands, and stream corridors.

Interdisciplinary research across natural and social sciences to address challenges in water resource management requires comprehensive and long-term data. As part of CEAP, a database called STEWARDS (Sustaining the Earth's Watersheds, Agricultural Research Data System) was developed to compile, document, and provide access to data from ARS research watersheds. These data represent one of the largest research watershed data collections in the world, with many of the watersheds offering decades of data required to address issues of climate variability and global change. STEWARDS represents an advance for hydrologic and environmental research by providing access to a multitude of data needed to support complex analyses. Anticipated impacts include increased productivity and collaborative opportunities for individual scientists, watershed teams, and the ARS water resources program and better accountability at the agency level for investment in long-term watershed research

ARS coordinates with other government agencies to leverage agency resources through its active participation in a variety of intergovernmental committees including: (1) the Committee on Environment and Natural Resources (CENR) (the relevant National Science and Technology Council committee for water research) Subcommittee on Water Availability and Quality (SWAQ), a subcommittee within CENR devoted to water issues that serves as a forum for agency representatives to share information about their respective programs; (2) the National Agricultural Research, Extension, Education and Economics (NAREEE) Advisory Board, which evaluates USDA Research and Development Programs and provides recommendations to the Secretary and REE Undersecretaries; (3) the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, charged by Congress with conducting a reassessment of (i) nutrient load reductions and the response of the hypoxic zone, (ii) water quality throughout the Mississippi River Basin, and (iii) economic and social effects, a draft of which is currently being circulated for public comment (4) the Advisory Committee on Water Information (ACWI) Subcommittee on Sedimentation; (5) the USDA Drought Team and the USDA Working Group on Water Resources; (6) the Conservation Effects Assessment Project Steering; The Subcommittee on Sedimentation, part of the US Department of Interior, Advisory Committee on Water Information; the Ecosystems Working Group of the US Climate Change Science Program, and several others.

Selected Accomplishments:

Problem Area 1—Effectiveness of Conservation Practices. Improved conservation practices contribute to reductions in losses of sediment and nutrients from agriculture. Ideal practices will reduce the cost of inputs for the producer, improve the sustainability of land resources, and minimize the impact of agriculture on water quality. Assessments of the impacts of conservation practices across large, complex watershed areas depends on the development of reliable assessment criteria, an understanding of the physical processes that occur within the field and watershed, and the integration of this knowledge into improved, validated models and tools to evaluate and predict the impact and result of management options.

Assessing the Effectiveness of Conservation Practices—The Importance of Riparian Forest Buffers. The 2002 Farm Bill tasked USDA with assessing the effectiveness of federally funded conservation programs through the Conservation Effects Assessment Project (CEAP). ARS scientists at Tifton, GA used the Soil Water Assessment Tool (SWAT) to simulate the water quality effects of upland conservation practices (CPs) commonly adopted in the Little River Experimental Watershed (LREW), GA, for either erosion or nutrient control, comparing these results with the simulated impact of riparian forest buffers currently in place in the LREW. Erosion CPs resulted in the greatest reductions in sediment and phosphorus while nutrient reduction practices were most effective in reducing total stream nitrogen. Three different prioritization scenarios for implementing CPs—random placement, stream order, and nonpoint source pollutant load—were also evaluated. Prioritizing based upon nonpoint source pollutant load yielded more efficient (nonlinear) water quality improvements while the other implementation schemes yielded linear returns. Riparian forest buffers offered the most comprehensive reduction of all three pollutants. Simulation results indicate that the current level of riparian forest cover in the LREW may be the single greatest contributor to nonpoint source pollutant reduction in this watershed. (202-5B / 211-1A; PM 6.1.1 & 6.1.2)

Parameterization of the ALMANAC (Agricultural Land Management Alternatives with Numerical Assessment Criteria) Model Increases the Accuracy of Biofuel Production Assessments for Grasses. For both conservation and biofuels assessment needs, simulating the growth and yield of grasses requires an accurate, realistic simulation model that describes various grass types as well as competition among species in complex grass mixtures. ARS researchers at Temple, TX added appropriate equations to the ALMANAC model for the major improved grass species and several common native grasses, including major grasses for planned for use as biofuel feedstocks. Developing these equations involved field measurements to determine leaf area per unit land area for each species, optimum leaf nutrient concentrations, and the efficiency with which each grass species converted sunlight into biomass. Through these investigations, appropriate equations were developed for switchgrass cultivars in Texas and in the Upper Midwest, and then validated against measurement data from a wide range of latitudes from Texas to North Dakota and Wisconsin. When subsequently incorporated into the ALMANAC model, these new equations provided realistic simulations of grass growth and productivity for a wide range of soils and climatic conditions. The model is currently being used by the Department of Energy and university scientists to assess potential biofuel productivity and sustainability of grasslands across the United States. (211-1A / 211-1F; PM 6.1.1)

Crop sensors improve nitrogen management in corn, reducing the need for fertilizer use. Since up to 70% of the nitrogen fertilizer applied to corn can be lost to the environment, there is an expanded effort to use precision application technologies for nitrogen fertilizer management in corn based production systems across the U.S. Canopy reflectance sensors enable precision application of the correct amount of nitrogen fertilizer variably across a field to meet the needs of a growing corn crop. ARS scientists at University Park, PA showed the potential to reduce nitrogen fertilizer applications by 16% relative to the best of conventional methods in fields across Pennsylvania, improving farmers' net return on valuable fertilizer dollars and reducing environmental impact. The method can provide instantaneous assessment of crop nitrogen status during fertilizer application, a "turnkey" feature that increases the likelihood of adoption by farmers. In cooperation with the University of Nebraska, ARS scientists at Lincoln, NE have developed equations to convert field variations in in-season readings from canopy reflectance sensors into variable N application rates across a field, producing a 15 to 40% savings in N compared to traditional practices. In addition, the new method requires only 2 or 3 sensors per 24-row applicator to monitor crop N status. As such, it should be relatively inexpensive to retrofit this technology to commercially available applicators. (211-1A / 211-1F; PM 6.1.1)

Hydrologic changes in the Midwest result more from shifts in climate than land use. Hydrologic shifts towards greater discharge have been observed in the Midwest, but it is uncertain whether this trend results from changes in agricultural land use or changes in climate. When evaluating simultaneous shifts in how energy (evaporative demand) and water (precipitation) were partitioned during a long-term, small-watershed experiment, the effects of land use (watershed treatment) and climate trend (time) became readily distinguishable. Applying the technique to four larger watersheds across the Midwest, increasing discharge was shown to be more attributable to climate change than to land-use change. Changes in land use, in particular increased soybean acreage, did show a shift towards increasing discharge that could be attributed to decreased crop water use. But since 1975, and after this change in cropping occurred, changing climate, in the form of increased precipitation and decreased evaporative demand, has been the dominant influence on watershed hydrology. This trend impacts issues such as Gulf of Mexico hypoxia, which expands as both nutrient losses and discharge increase. Results should be of interest to all groups interested in conservation effectiveness in the Midwest (i.e., conservation groups, policy developers, environmental and commodity groups), because increased discharge from agricultural watersheds due to climate change inherently increases the challenges of retaining agricultural nutrients within soils. (211-1A; PM 6.1.1)

Phosphorus leaching losses can be controlled with well-placed tillage. Phosphorus in surface waters contributes to the nutrient load that may lead to hypoxic conditions. As a component of animal manures, phosphorus can be recycled by application on lands used to grow forage or cover crops. Keeping phosphorus in land-applied manure from leaching to tile drains or to nearby drainage ditches is a major water quality concern. A new manure injection technology with special features to minimize liquid manure leaching was tested on Maryland's Eastern Shore. Phosphorus leaching losses were lowered by more than 40% with the new technology relative to conventional methods. The technology was so effective that leaching losses were even lower than those measured on soils that were not fertilized with manure. Results demonstrate the potential to readily manage environmental losses of manure nutrients with new manure application technologies. (211-1A: PM 6.1.1)

Grass filter strips effectively control herbicide runoff. The Mark Twain Lake/Salt River Basin was selected as one of 12 USDA-Agricultural Research Service benchmark watersheds for the Conservation Effects Assessment Project (CEAP) because of documented soil and water quality problems and broad stakeholder interest. The basin is characterized by the predominance of claypan soils that result in especially high vulnerability to soil erosion and surface transport of herbicides. Studies using cropping system best management practices showed that no-till cropping systems did not reduce surface runoff compared to tilled systems and led to increased transport of soil-applied herbicides. Planting grass filter strips with warm and cool season grasses reduced herbicide transport in surface runoff, thereby improving water quality. (211-1A; PM 6.1.1)

Satellite derived mapping effectively evaluates conservation practices. Conservation tillage is a commonly adopted best management practice for improving soil quality and reducing erosion. However, there are currently no methods in place to monitor conservation tillage adoption at the watershed scale. Using commonly available satellite imagery, a mapping algorithm was developed that depicted conservation tillage adoption within the Little River Experimental Watershed. The resulting map identified farm sites using conservation tillage (defined as having >30% crop residue cover) with 71-78% confidence. Results are encouraging and suggest that currently available satellite imagery can be used to map conservation tillage adoption with a minimum amount of ground control points. (202-3C/202-5B/ 211-1A)

Problem Area 2—Irrigation Water Management. Irrigated agriculture produces 60% of crop market value on less than 20% of the cropped land and mitigates the impact of drought. Improving the efficiency of irrigation practices can increase the availability of water for other uses (urban, industrial, ecosystem, recreation and the environment). As demand for biofuel feedstock increase there is increasing pressure to produce more food on less land using irrigation technologies. The increased demand for water from all sectors leads to an emphasis to produce more crop per drop and to increase the efficiency of irrigation practices. Climate change induced variations in precipitation and snowmelt also place a greater need for efficient methods to trap, store, and deliver water needed for irrigation.

Remote Sensing Helps Manage Efficient Irrigation of Crops. Remote sensing imagery can be used to develop a crop vegetation index for every section of a grower's field. This index can then be used to manage efficient and precise irrigation to crops, but the number of times aerial imagery is needed during the season is not cost-effective. ARS scientists at Maricopa, AZ used a statistical procedure to place 12 low-cost sensors that collect daily vegetation index data. Information from this small number of field sensors accurately predicted the vegetation index at 17,000 locations within the field, providing an effective, low cost tool for irrigation water management while decreasing the need for additional aerial imagery. (211-1B / 211-1E; PM 6.1.1)

Infrared Canopy Temperature Guides Deficit Irrigation in Peach Orchards. Deficit irrigation is a management method to conserve water and energy by supplying only the amount of water necessary to meet crop demands. ARS scientists at Parlier, CA measured canopy temperature as an indicator of drought stress in a peach orchard, using thermal infrared sensors. Results showed that average maximum canopy temperature was significantly higher for treatments that received deficit drip and furrow irrigation than those receiving full irrigation. Despite these higher temperatures, deficit irrigation saved over 50% of the water used with no significant impact on peach yield or quality. The study clearly demonstrated that infrared canopy sensors can be used as an onsite guide for managing deficit irrigation in orchard crops. (211-1B; PM 6.1.1)

Wireless Network Developed to Automate Center Pivot Systems. As available water in the Ogallala Aquifer declines, new irrigation technologies that improve crop production with less water are needed to maintain current levels of farm income. Irrigation systems that apply water to crops based on plant need are among these new technologies. ARS scientists from Bushland, Texas, have developed, constructed, and tested a wireless control system for an automated moving sprinkler irrigation system. This system is designed to work on a six-span, center pivot, sprinkler irrigation system. Automatic irrigation scheduling can aid farmers in decreasing water use, while improving time management, and decreasing energy costs and greenhouse gas emissions. (211-1B; PM 6.1.1)

New Method Developed for Controlling Large Irrigation Canals. Irrigation represents a major water use in semiarid regions, so efficient water delivery systems are critical. Water delivery is either controlled upstream by measuring differences in inflows and outflows, or by flow measurements made downstream. Upstream control results in operational spills while downstream control is difficult to implement in practice because of long travel times from the water source to the main canal, constraints imposed by the water supplier, or because the inflow is determined by variable river flow. ARS scientists and engineers at Maricopa, AZ developed a method to distribute flow mismatches over the canal length by equalizing water level errors for all canal pools. This strategy, which is essentially a combination of upstream and downstream control, promises to facilitate automated canal operations, providing a more flexible and accurate water supply to irrigators while reducing operational spills. The strategy has been implemented via the Software for Automated Canal Management (SACMAN) program. (211-1B; PM 6.1.1)

Groundwater Model Calibrated for Northern High Plains of Texas. Water planning and decision making requires precise estimates of current groundwater reserves and a means of projecting withdrawal rates under various water use scenarios. The Legislature of Texas has established a water use planning process in the Northern High Plains of Texas, where the Ogallala Aquifer is the most significant source of water. ARS scientists in Bushland calibrated a groundwater model for a four-county area (Dallam, Sherman, Hartley, and Moore counties) in the Northern High Plains, comparing estimated and actual water levels in the Ogallala Aquifer prior to intensive irrigation withdrawals. The calibrated model will be used to evaluate water conservation strategies and the results will be useful in guiding regional water planning activities. (211-1E; PM 6.1.1)

Bed Planting Potato to Improve Water Conservation. In irrigated potato production systems, potatoes are planted in ridge-rows. The deep furrows between the ridge-rows are needed for drainage under rain-fed conditions but also function to drain water under modern sprinkler irrigation. The Northwest Irrigation and Soils Research Laboratory in Kimberly, Idaho, has cooperated with private industry and potato producers to demonstrate advantages of bed-planted potatoes on more than 10,000 acres in Idaho during the past three years. Side-by-side field comparisons of potatoes planted in conventional ridge-rows versus 12-foot wide, five-row beds have shown that bed-planting potatoes can decrease irrigation water use 5 to 15% with equal or increased potato yield.

Improved surface irrigation model developed. Analysis of the performance of surface irrigation systems relies on mathematical models of the hydraulic flow processes. The ARS WinSRFR model predicts surface flows based on physical principles, but uses indirect methods to predict infiltration, and does not account for initial soil water conditions. Because of this, WinSRFR cannot be used to model solute transport processes induced by irrigation. Researchers have previously proposed ways to combine models of both surface and subsurface flow that are based on physical principles, but the procedures are both complex and problematic. ARS scientists at Maricopa, AZ developed a simple and robust method to combine the physical principles infiltration model, HYDRUS-1D, with WinSRFR. ARS scientists are incorporating this method into version 4 of WinSRFR, for delivery to USDA-NRCS and other users who require this type of analytical capability. (211-1E / PM 6.1.1)

Problem Area 3—Drainage Water Management Systems. Specific guidelines and tools are needed for nutrient and pesticide management in both surface and subsurface drainage water management systems. Automation of these systems, including the integration of weather forecasts, could enhance water conservation benefits during short-term drought periods in humid areas. Long-term soil quality improvement, increased water availability (quantity and quality), and wildlife benefits are all possible with improvements in wetland management practices. Improved drainage water management can also improve water use efficiency in irrigated agriculture while reducing the long-term effects of salinity and trace elements under different cropping systems. The combined effects of improved subsurface drainage water management practices and alternative cropping systems for irrigated agriculture need to be incorporated into an environmental and economic decision support system that fully evaluates the cost-effectiveness of these systems.

Benefits of Controlled Drainage Demonstrated. The Midwestern States have millions of feet of conventional drainpipe systems placed at 3.5-4.0 ft. depth. Subsurface drainage flows from cropland have been identified as a major source of fertilizer nutrient (nitrate-nitrogen) loss. Early model simulations indicated that shallow subsurface drainage systems may be more effective in reducing nitrate loss, but field research conducted over several years has demonstrated that conventional depth subsurface drainpipe systems equipped with an outlet structure to control discharge are as effective as shallow drainpipe systems in reducing nitrate losses. Retrofitting deeper drains with an outlet pipe structure to control drainage flow could significantly reduce nitrate losses from croplands that discharge into the Mississippi River Basin, reducing the contribution of agricultural drainage to the development of the hypoxic zone in the Gulf of Mexico. Many new and retrofitted drainage systems have already been implemented for controlled drainage in the Midwest. (211-1C / 211-1F; PM 6.1.1*)*

Flooding Tolerance Improved in Soybean. Flooding stress is second only to combined heat and drought stress as a major cause of economic losses to US agriculture. Soybeans are sensitive to flooding stress. The most common cause of flooding in soybean fields is due to ponding in low-lying areas during heavy rains. Flooding stress reduces soybean yields, and therefore crop revenues, by initiating the early onset of plant senescence (i.e., plants stop growing before they have fully matured). In cooperation with the University of Missouri, ARS scientists developed transgenic soybean lines containing an anti-senescence gene, and used a series of greenhouse experiments to compare the impacts of flooding on the productivity of transgenic and non-transgenic soybean lines. Under flooded conditions, transgenic plants generally remained green and healthy during the late pod-filling stage and produced twice the seed yield of non-transgenic plants. This research could lead to the development of commercial soybean cultivars that are more tolerant of flooded conditions, generally improving soybean yields. (211-1C; PM 6.1.1)

Industrial Product Used to Filter Contaminants from Drainage Water. In both small and large agricultural settings, filter treatment systems can remove nutrients and pesticides from water discharged by subsurface drainage systems. The success of these systems depends on finding inexpensive filter materials capable of effectively and efficiently removing nutrients and/or pesticides. ARS scientists in Columbus, OH, found that a relatively new industrial product has potential as a filter material for agricultural water treatment. As tests showed, sulfur modified iron is sufficiently permeable to water flow to be effective/efficient in removing nitrate and phosphate from water. When combined in series with another filter material, such as zero valent iron or activated carbon, sulfur modified iron can also remove the pesticide, atrazine, from water. Consequently, sulfur modified iron used alone or in combination with other filter materials may in the future prove valuable for reducing the adverse environmental impacts associated with agricultural subsurface drainage practices. (211-1F; PM 6.1.1)

Drainage-water Reuse System Remediates Selenium and Produces Biofuels. At high concentrations, selenium in the soil is toxic to most organisms. ARS scientists in Parlier, CA, identified various plant species, including poplar tree clones, that were capable of growing in the west side of the San Joaquin Valley of California in areas with underlying poor water quality due to high selenium concentrations, to support sustainable drainage water reuse. Oil-plant species produced 1.5 tons of seed/acre as bio-based product that provides economic value for the grower (e.g., bio-fuel and Se-enriched feed products after extracting the oil from the seeds with an on-site oil press). Within the same drainage-water management system, annual poplar tree cuttings served as feedstocks for gasification. These studies illustrate ways to use an agronomic-based system as part of an overall drainage-water reuse strategy. Such a system could find widespread usage in portions of central California where selenium toxicity is an issue. (211-1F; PM 6.1.1)

Problem Area 4—Integrated Soil Erosion and Sedimentation Technologies. Soil erosion, sediment movement, and deposition processes involve the interactions of land management practices with climate, soil, and landscape properties. Because erosion affects soil properties progressively over time and generally results in decreased soil quality and reduced resistance of agricultural systems to stresses, soil erosion control is essential for sustainable agricultural production systems. Sediment generated by soil erosion has costly, negative off-site impacts on downstream channel evolution, flooding, and water and air quality. Better erosion control technologies and improved decision support systems for planning and assessment are needed. In both cases, local effects on a field, farm, or channel and off-site impacts at the larger watershed scale are necessary.

Non-contact Technique Developed to Measure Soil Properties. Models that predict the benefits of conservation practices, erosion, and crop growth depend on soil physical properties that are time consuming and expensive to measure. Acoustic properties of soils have been shown to be indicative of soil physical properties. In collaboration with the National Center of Physical Acoustics, ARS scientists at Oxford, MS have demonstrated a rapid, multi-channel analysis of a surface wave method that uses laser Doppler vibrometry as a non-contact sensor to obtain the sound speed profile in soil up to 10 feet below the surface. Temporal variations of the soil profile due to changes in moisture content have been evaluated non-invasively. Sealing/crusting of the surface layer of the soil (less than 2 inches below surface) was detected based on higher sound speeds than those of lower-layer soils. This method has the potential to measure soil properties at different depths, depending upon the wavelength, in a rapidly deployable, easily moveable, non-contact manner without disturbing the soil. (211-1E; PM 6.1.1)

The Water Erosion Prediction Project (WEPP) Improved for Frozen Soils. The WEPP model is important in assessing the impact of human activities such as agricultural production, forest harvesting and land development on water erosion and runoff. However, studies have revealed inadequacies in WEPP in predicting runoff and erosion under winter conditions. In cooperation with Washington State University scientists, ARS scientists at Pullman, WA, improved WEPP to better simulate soil freeze-thaw and winter runoff and erosion. The National Resource Conservation Services (NRCS) and other agencies and private consultants can now use WEPP with greater confidence in cold regions where soils freeze and thaw. (211-1D; PM 6.1.1)

New Group of Models Shows How Riparian Vegetation Stabilizes Stream Banks. Stream bank material can be a dominant source of stream sediment in many watersheds. Apart from the impact of increased soil water content on bank properties, scientists have largely ignored subsurface flow as a cause of bank failure. Field measurements, laboratory experiments and mathematical models have all shown that undercutting of stream banks by seepage erosion can be a significant mechanism of bank failure. As water levels in streams fall following a rain event, documenting stream bank failure caused by undercutting due to seepage erosion is the basis for a new group of models that include this subsurface flow process. ARS scientists are developing datasets of soil pore-water pressures under conditions of subsurface flow for locations with and without deep-rooted riparian vegetation. Stream bank stability models with a seepage component more realistically evaluate the benefits of riparian vegetation in stabilizing stream banks. (211-1D; PM 6.1.1)

New Model Quantifies Reductions In Stream Bank Erosion From Management and Mitigation Strategies. The use of riparian buffers to stabilize stream banks and reduce the loss of agricultural land and sediment loadings to streams has become a popular management technique, but accurately quantifying the reinforcing effects of vegetation on bank stability and sediment losses is difficult. ARS scientists collected field data on root strength and root distributions for a broad range of riparian species, applied these data to a type of reinforcement model used in structural engineering, verified their approach with laboratory experiments, and then incorporated their findings into a bank-stability model. The resulting model allows users to determine stable bank configurations, how different types of vegetation affect bank stability, resulting sediment losses from stream banks, and the reductions in sediment loss expected under a variety of mitigation strategies. Stream banks are a major source of sediment in disturbed streams. This new model allows users to predict and accurately quantify changes sediment (and land) losses from stream bank erosion under a variety of conditions and management options. (211-1D; PM 6.1.1)

Spillway Design Models Optimize Flood Control and Safety. Increasing the flow capacity of the numerous flood control dams that exist in small watersheds is a growing issue for rehabilitating these aging structures and maintaining their safety. NRCS engineers are using Roller compacted concrete (RCC) stepped spillways to increase flow capacity, protect these earthen dams from potential erosion. One important design issue is determining the dimensions of the vertical and sloped training walls needed when the spillway chute is required to be narrower at the bottom than at the top. Because RCC spillways cost several million dollars to build, research providing optimal design criteria for these spillways could save a significant amount of money. During FY09, ARS scientists completed a series of generalized model studies resulting that produced a series of equations to predict the appropriate dimensions of converging vertical and sloped sidewalls, to achieve maximum safe flow capacities in earthen dam spillways, thereby minimizing potential costs. (211-1D; PM 6.1.1)

Problem Area 5—Watershed Management, Water Availability, and Ecosystem Restoration. Agricultural lands, including crop, pasture, and range lands, constitute over 70% of the continental U.S. and play a dominant role in the management of the Nation's watersheds and the water resources needed for human consumption, recreation, agriculture, industry, wildlife habitat, aquatic ecosystems and a healthy environment. The confluence of unprecedented demands for freshwater, rapidly changing land use to accommodate rural and urban growth and biofuel production, recurring droughts, and regional climatic variations means that the Nation's freshwater resources, agricultural production and ecosystems are under more pressure and at greater risk than ever before. Thus, there is a need to accurately quantify and manage our water resources to support these many uses across heterogeneous agricultural and urban landscapes. Watershed management based on multiple objectives that include water supply, water pollution, urban development, climate variability, recreation, ecosystem protection and habitat restoration is a complex task necessary not only to support the goals of the Clean Water Act and the Endangered Species Act, but also to address concerns of watershed coalitions, policy makers and the public.

All-Weather Satellite Monitoring System Improves Global Agricultural Forecasts. Accurate knowledge of vegetation condition is important for assessing agricultural production and forecasting yield. Satellites could collect this information, but conventional satellite-based vegetation sensors can only collect data during daylight and cannot "see" through clouds. Many parts of the world are plagued with almost constant cloud cover. ARS scientists at Beltsville, MD developed a way to use microwaves to quantify vegetation condition regardless of weather, using currently operational satellites. Because microwaves are sensitive to properties of the entire canopy rather than just the leaves, microwave data can provide significant new information about vegetation condition and in many cases can "see" through plant canopies. Microwaves provide a complementary dataset to conventional satellite data that improves our capacity to monitor global agricultural productivity from space. This information has the capacity to improve the timeliness and reliability of crop condition assessments and yield forecasts made by USDA's Foreign Agricultural Service and other agencies both in the U.S. and worldwide, with significant implications for improving international food security and agricultural adaptation to global climate change. (211-1E; PM 6.1.1)

Alpha Testing of Computer Engineering Tool WinDAMb Completed. Through a cooperative effort, USDA-ARS-Hydraulic Engineering Research Laboratory, Natural Resources Conservation Service, and Kansas State University scientists completed the alpha testing of the computer engineering application tool WinDAMb. Enhancements allow users to evaluate a number of important factors contributing to the safety and effective operation of homogeneous earthen embankment dams (e.g., timing and location of breaches, erosion caused by embankment overtopping, and flood discharge). This computer tool will be important in evaluating existing structures, with potential for determining hazard classification, emergency action plans, and reducing costs associated with rehabilitation. (211-1D; PM 6.1.1)

Development of a Geographic Information System (GIS)-based Tool Box for Integrated Watershed Management. It is difficult for watershed managers to obtain the best information on how to maintain productivity while reducing downstream impacts. ARS scientists developed a GIS-based toolbox with a friendly Graphical User Interface for engineers. This Integrated Model System and Decision Support System searches for the best land use scenario that will minimize sediment yield and nutrient concentrations at key locations. The model compares total operation/implementation costs against water quality and production benefits. Having passed through the initial testing phase, the toolbox is now being refined for release to the public for testing by users. When fully developed, this system will be useful to agricultural as well as other types of land managers. (211-1D; PM 6.1.1)

Acoustic Attenuation Used for Measuring Fine Suspended-sediment. Accurately measuring sediment concentrations in streams draining agricultural watersheds is important for quantifying erosion losses, assessing the impacts of sediment on the dynamics of stream and river flow, and predicting sediment buildup behind dams and in reservoirs, but sediment measurements are both difficult and expensive to collect. In collaboration with the National Center for Physical Acoustics, ARS scientists in Oxford, MS developed a way to measure fine sediment particles (< 0.062 mm) in water acoustically. This new technology will enhance current capabilities for measuring suspended sediments in water, closing a gap in acoustic measurements of particles less than 0.062 mm in diameter. The technology allows remote, autonomous deployment, is relatively inexpensive, and gives much more detailed information about sediment dynamics than traditional manual sampling techniques. (211-1D; PM 6.1.1)

Problem Area 6—Water Quality Protection Systems. Nutrients and pesticides (insecticides, herbicides, fungicides) applied to agricultural fields, and pharmaceuticals (antibiotics and hormones) used in livestock production, can move from their point of use into surface and ground waters, where their presence raises concerns about their impact on aquatic and terrestrial ecosystems and human health. To evaluate fully the risks of using these chemicals and compounds in agriculture, there is a need to know their sources, transport behavior, fate, and biological impact at different concentrations and in different combinations in the environment. ARS conducts research to better understand and predict the source, fate, transport and environmental effects of nutrients, emerging contaminants and inorganic ions. This work provides the basis for the development of best management practices across a range of climates, soils, and agricultural and urban settings. To better design and refine existing practices, new scientific information needs to be developed that clearly delineates how agricultural contaminants move and are transformed within the environment.

Wood Chip Bioreactors Reduce Nitrate Exports From Agricultural Watersheds. Large quantities of nitrate can be lost from agricultural watersheds in subsurface drainage. Concentrations frequently exceed10 parts per million. Field studies have shown that passing water through buried wood chips removes most of the nitrate, but many factors, particularly variations in water flow and nitrate concentration, can influence the effectiveness of nitrate removal. Under controlled laboratory conditions, ARS scientists at Ames, IA investigated the ability of wood chips to remove nitrate from water at flow rates representative of waters entering subsurface drainage tiles in the field. Complete nitrate removal occurred at the lowest flow rate, but only 30% was removed at the highest flow rate. Microbial conversion of nitrate to inert molecular nitrogen gas (i.e., denitrification) was the dominant nitrate removal mechanism; amounts of nitrous oxide, an important greenhouse gas produced during denitrification, were not environmentally significant. Knowledge of these relationships can be used to improve the design of wood chip bioreactors to reduce nitrate exports from subsurface agricultural drainage systems, with significant implications for reducing agriculturally-derived nitrate exports from tile-drained agricultural watersheds. Research and extension scientists are already working with producers and environmental groups to test these kinds of wood chip bioreactors in the field. (211 -1F; PM 6.1.1)

Development and Testing of Process-based Models. Process-based computer models are important tools for studying and predicting the fate and transport of agricultural contaminants in soils and groundwater, and for designing optimal soil, water or crop management practices. ARS scientists at Riverside, CA released a new version of the HYDRUS-1D (version 4.0) software package that includes new or improved capabilities for simulating a variety of processes associated with contaminant transport. The new features make the software more suitable for application to a broad range of agricultural and industrial subsurface pollution problems. (206-4C/ 211-1B; PM 6.1.1)

Waste Water Recycled at a Latex Extraction Facility. Wastewater from a processing plant that extracts latex from guayule is difficult to dispose of due to its alkalinity (pH >12), odor, and the presence of hydrophobic organics. ARS scientists at Maricopa, AZ determined that up to 50% of the wastewater could be recycled within the processing plant without affecting latex recovery. Treating the resulting wastewater with acid followed by sedimentation removes the odor and the hydrophobic organics and lowers the alkalinity. Because it contains both nitrogen and potassium, the treated wastewater has the additional benefit of being useful as a fertilizer. Overall, the process increases the economic viability of domestic latex and rubber production. (211-1E; PM 6.1.1)

Survival of E. coli in Stormwater. The presence of pollutants in water resulting from monsoonal flows is of concern because these waters move from riverbeds to recharge basins, where they replenish depleted groundwater supplies. A collaborative study between ARS scientists at Maricopa, AZ and University of Arizona focused on the transport of chemical contaminants and survival of E. coli in stormwater flows in Tucson, Arizona. The two-year study revealed that as stormwater moves through urban Tucson stream beds, levels of organic pollutants decrease, but E. coli levels increase. This information is important for sustainable urban water resource management in semiarid region. (211-1E; PM 6.1.1)